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Roerdink, Melvyn; Stins, John F.

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Letter to the Editor: On "Advantages and disadvantages of stiffness instructions when studying postural control" by C.T. Bonnet: Taking a step towards a broader perspective on quiet standing instructions

Melvyn Roerdink*, John F. Stins

Department of Human Movement Sciences, VU University Amsterdam, Amsterdam, The Netherlands
E-mail address: m.roerdink@vu.nl (M. Roerdink).

In his Letter to the Editor, Bonnet [1] addressed an important issue for experimental studies on postural control, related to the way we typically instruct our participants on how to stand still during a measurement. As all behavioral scientists are aware, instructions are very influential in guiding participants' behavior in the lab. An implicit assumption is always that the participant (a) understands the instruction, (b) is willing to do as s/he is told, and (c) actually behaves as requested by the experimenter. Unfortunately, as scientists we often have little control over these processes.

Bonnet [1] discussed several advantages and disadvantages of a specific instruction, namely the stiffness instruction, also known as the steadiness requirement. He arrived at the conclusion that one should refrain from instructing participants to stand as still as possible if one aims to study "natural postural control". This conclusion is legitimate because such a stand-as-still-as-possible instruction is likely to induce changes in the manner in which participants regulate their posture compared to "natural postural control" (i.e., a stiffer or tighter postural control; [2,3]). However, the overarching issue regarding participant instructions on how to stand still during measurements remains implicit in Bonnet's Letter to the Editor [1]. We don't have a solution for this issue. Rather, we posit that instructions play a well-defined role in the study of postural control, of which the stiffness instruction is just one of the many possible instructions within a broader set of factors influencing postural control. We illustrate this by discussing a basic study

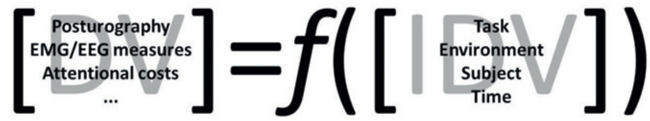

Fig. 1. Study design scheme with a set of dependent variables DV as a function of a set of independent variables IDV.

design scheme with pertinent independent variables (IDV) and dependent variables (DV) for examining "natural postural control" (Fig. 1).

IDV: Natural postural control varies as a function of tasks, context, subjects and time

Bonnet [1] apparently views "natural postural control" as a distinct type of postural control that qualitatively differs from a stiff or tight postural control. We consider "natural postural control" not as an invariant type of control, but as a time-dependent context-specific type of control that changes with task and subject variations. For example, standing in a cue for the coffee machine seems a less demanding postural control task than standing while holding a cup of hot coffee filled to the rim. Likewise, changes in environmental context also shape the way in which individuals control their posture. Standing in a big empty room places different demands on postural control than standing on a slippery surface at the edge of a cliff. These four examples can all be regarded as examples of "natural postural control", because the way posture is controlled is selected by the actor and not by an experimenter. Note that in some situations, such as standing at the edge of a cliff, a stiffer control may in fact be selected as a naturally protective strategy [4]. In an experimental context, these variations in task and environmental context are our within-subjects IDV under examination (e.g., [5]).

Note that for the same task and the same environmental context, participants differing in for example body configuration [6] or personality traits [7] may control their posture very differently. Subject variations can thus be regarded as another important IDV that is often incorporated as a between-subjects factor, for example to examine the effects of expertise and disease on natural postural control [8–10]. Finally, postural control may change over time, such as in the course of development [11,12], aging [13], weight loss [14], rehabilitation [9,15] or even measurement duration [16], yielding another between-subjects (for cross-sectional studies) or within-subject (for longitudinal studies) source of variation. To fully understand "natural postural control", an encompassing examination of postural control against several IDVs is required. Given that the demands placed on postural control vary as a function of abovementioned IDVs, it seems fair to conclude that "natural postural control" should not be regarded as a distinct type of control. In other words, natural postural control likely contains multiple postural control solutions, including stiffening, which may vary over time, subjects, tasks and environments.

DV: Natural postural control is more than just the amount of postural sway

Bonnet [1] focusses exclusively on the amount of center-of-pressure (COP) excursion as a marker of postural control. Although the amount of postural sway can be easily recorded with COP registrations, researchers now realize there may be limits as to what it can tell us. For example, the same amount of postural sway may result from very different postural control strategies, suggesting that a complementary set of DVs of postural control is needed to fully capture its context-dependent nature. Nowadays, COP registrations are often complemented with EMG measures and/or measures of cortical activity, allowing a better understanding of how intermuscular coordination of balance is regulated [17–21]. Also direct and indirect measures of the attentional investment in postural control are often used, such as stimulus-response reaction times or the regularity of COP excursions [10,22–25]. For example, if human subjects do indeed adopt an attention-demanding stiffness strategy when instructed to stand as still as possible, as suggested by Bonnet [1], this should be evident in higher co-contraction, greater cortical (prefrontal) activity, longer stimulus-response reaction times and more regular COP excursions compared to a neutral control instruction. Note that the amount of sway may be comparable between the two types of instructions. To fully understand "natural postural control", one should rely on a comprehensive set of DVs of postural control, instead of simply equating postural control with the amount of postural sway.

[DV] = f([IDV]): The well-defined role instruction plays in the study of postural control

In our view, an encompassing study of postural control requires an examination of the effects of various IDVs on a comprehensive set of DVs of postural control, as outlined in Fig. 1. The role of instruction in this scheme is well-defined and functions as one particular IDV (tasks) within the broader set of IDVs (task, environment, subject, time). That is, an instruction may function as a within-subject factor to study the effects of specific task instructions on postural control DVs. This could involve–in the context of Bonnet's Letter to the Editor–an experimental contrast between the task instructions "to stand as still as possible" and "to stand naturally upright" (cf. [2,3]). Experiments that manipulate instruction are widely available in the postural control literature, such as studies on internal vs. external foci of attention [26–28]. Researchers should of course explain the rationale behind their instructions as IDV in their papers, and as well specify the employed instructions. Outside the [DV] = f([IDV]) scheme, instruction may act as a controlled study parameter, similar to parameters such as the type of equipment and the sampling frequency, which are held constant. As already mentioned by Bonnet (2015), such instructions may be used for data quality control, for example by instructing participants to keep the feet in place and to prevent excessive head and arm movements while standing upright. Such instructions are convenient for both researchers and participants.

In conclusion, we do not see any merit in disregarding a specific instruction from being used in the lab, as proposed by Bonnet [1] regarding the stiffness instruction, provided that the instructions are explicitly specified in the paper. We fully agree with Bonnet [1] that it is worthwhile to study "natural postural control", which in our view requires an examination of the effects of various IDVs on a comprehensive set of postural control DVs (Fig. 1). Hence, we posit that maintaining an upright posture (inside and outside the lab) always takes place within a particular context, and that the instruction to the participant represents just one factor (i.e., task constraint) in an even broader set of IDVs influencing "natural postural control". Because of the well-defined role instructions play in the study of postural control, we see no reason to a priori exclude a particular type of instruction from the scientific investigation of postural control.

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